

A close-up photograph of a green leaf, showing a dense network of veins. The main veins are highlighted in a bright yellow color, while the smaller veins are a lighter green. The leaf's surface has a fine, reticulate texture.

Photosynthesis

A Concept Overview for SBI4U

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Concept Overview Agenda

- * Introduction and Hook
- * Curriculum Expectations
- * Concept Overview Mindmap
- * Misconceptions on Photosynthesis
- * Photosynthesis Unit Overview (Lessons 1-6)
 - * Activities and Assessment/Evaluation
- * Safety Considerations: Chlorophyll Chromatography
- * Applications and Societal Implications: Climate Change and Invasive Plants

The Photosynthesis Song

- A fundamental process!
- http://www.youtube.com/watch?v=CI_uez5WXIo



Curriculum Expectations

Overall Expectations

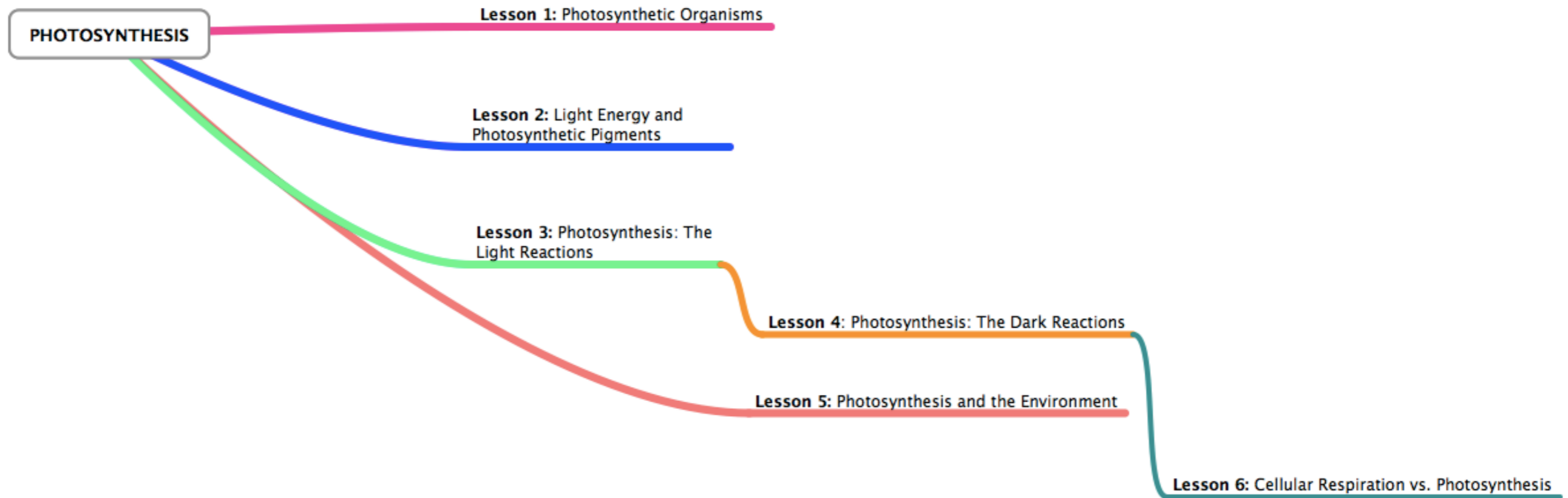
- * **C2.** investigate the products of metabolic processes such as cellular respiration and photosynthesis
- * **C3.** demonstrate an understanding of the chemical changes and energy conversions that occur in metabolic processes

Curriculum Expectations

Specific Expectations

- * **C2.3** conduct a laboratory investigation of the process of photosynthesis to identify the products of the process, interpret the qualitative observations, and display them in an appropriate format
- * **C3.2** explain the chemical changes and energy conversions associated with the process of photosynthesis (e.g., carbon dioxide and water react with sunlight to produce oxygen and glucose)
- * **C3.3** use the laws of thermodynamics to explain energy transfer in the cell during the processes of cellular respiration and photosynthesis
- * **C3.4** describe, compare, and illustrate (e.g., using flow charts) the matter and energy transformations that occur during the processes of cellular respiration (aerobic and anaerobic) and photosynthesis, including the roles of oxygen and organelles such as mitochondria and chloroplasts

Concept Overview: A Mind Map



A Misconceptions

Misconceptions	Suggestions
Students are confused with the terminology of: food, starch, sugar, glucose	Use these words interchangeably during the lessons so that students become comfortable with them
Photosynthesis occurs only in green plants	All plants have chloroplasts. Therefore all plants undergo photosynthesis
Plants obtain energy directly from the sun	Photons are absorbed by photosystems and excited electrons through photoexcitation and they enter the electron transport chain
Plants do not respire or they only respire at night	Explain that photosynthesis has light <u>independent reactions</u> and can respire at night
The world's supply of oxygen is in danger of being used up	Oxygen is limitless. High amounts of CO ₂ emissions is what is causing climate change

Lesson Sequence

- * **Lesson 1:** Photosynthetic Organisms
- * **Lesson 2:** Light Energy and Photosynthetic Pigments
- * **Lesson 3:** Photosynthesis: The Light Reactions
- * **Lesson 4:** Photosynthesis: The Dark Reactions
- * **Lesson 5:** Photosynthesis and the Environment
- * **Lesson 6:** Photosynthesis vs. Cellular Respiration: Jeopardy Game

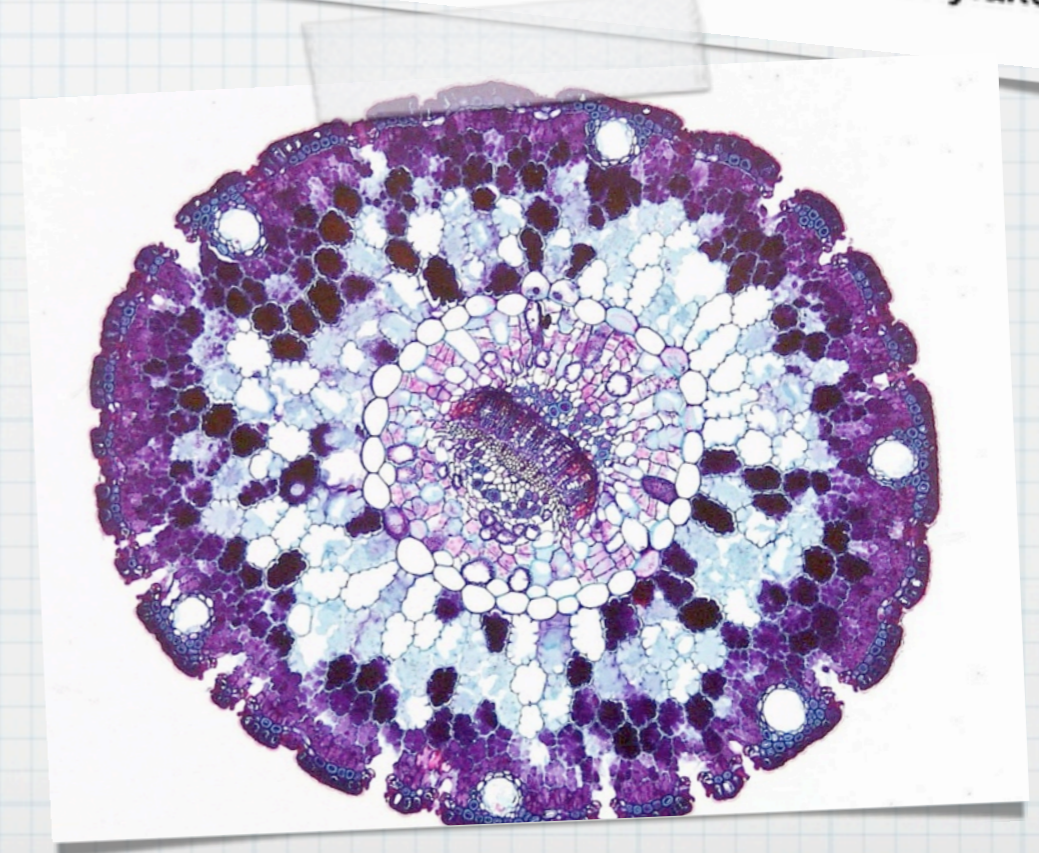
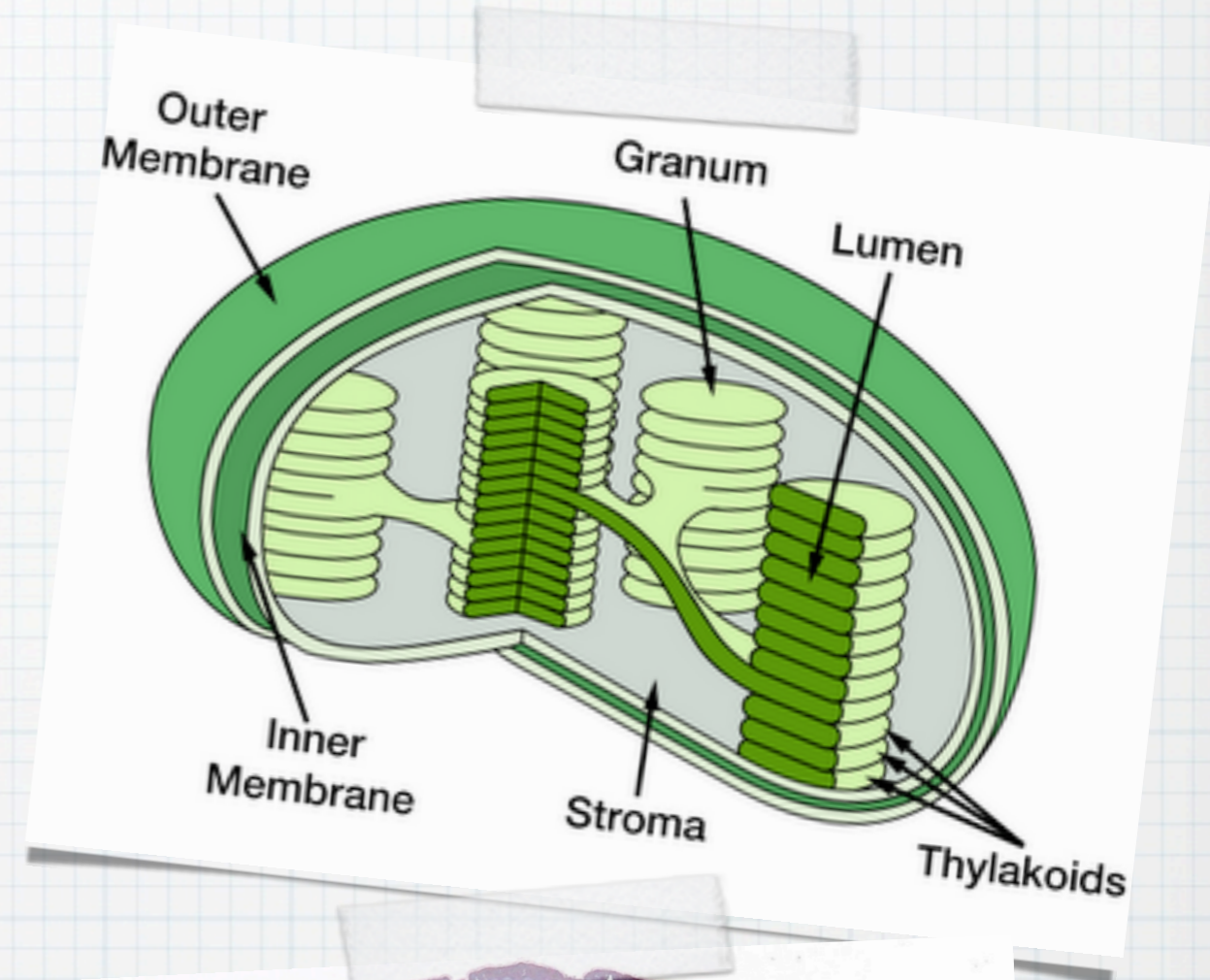
Lesson 1: Photosynthetic Organisms

Topics Covered

- * Chlorophyll
- * Prokaryotic Autotrophs: Cyanobacteria
- * Eukaryotic Autotrophs: Algae, Photosynthetic Protists and Plants
- * Leaves: The Photosynthetic Organs of Plants
- * Transpiration and Photosynthesis
- * Opening and Closing of Stomata
- * Chloroplasts

Assessment - Formative

- * Venn Diagram: Eukaryotic vs. Prokaryotic Plants
- * Computer Lab Activity: Gizmo - Energy Cell Cycle; Growing Plants



Lesson 2: Light Energy and Photosynthetic Pigments

Pigment	Wavelength Absorbed (nm)	Wavelength Reflected (nm)	Location	Function
Chlorophyll a	425 – 475 625 - 700	500 – 600	Chloroplast	Transmits energy to carbon fixation reactions
Chlorophyll b	425 – 475 625 - 700	500 – 600	Chloroplast	Absorbs light energy
Beta carotene	400 - 500	625 - 700	Chloroplast	Absorbs light energy and loses it as heat
xanthophylls		yellow	Chloroplast	Absorbs light energy - turns leaves yellow in the fall
anthocyanis		Red, violet, blue	Vacuole	Absorbs light energy - Turns leaves red in the fall

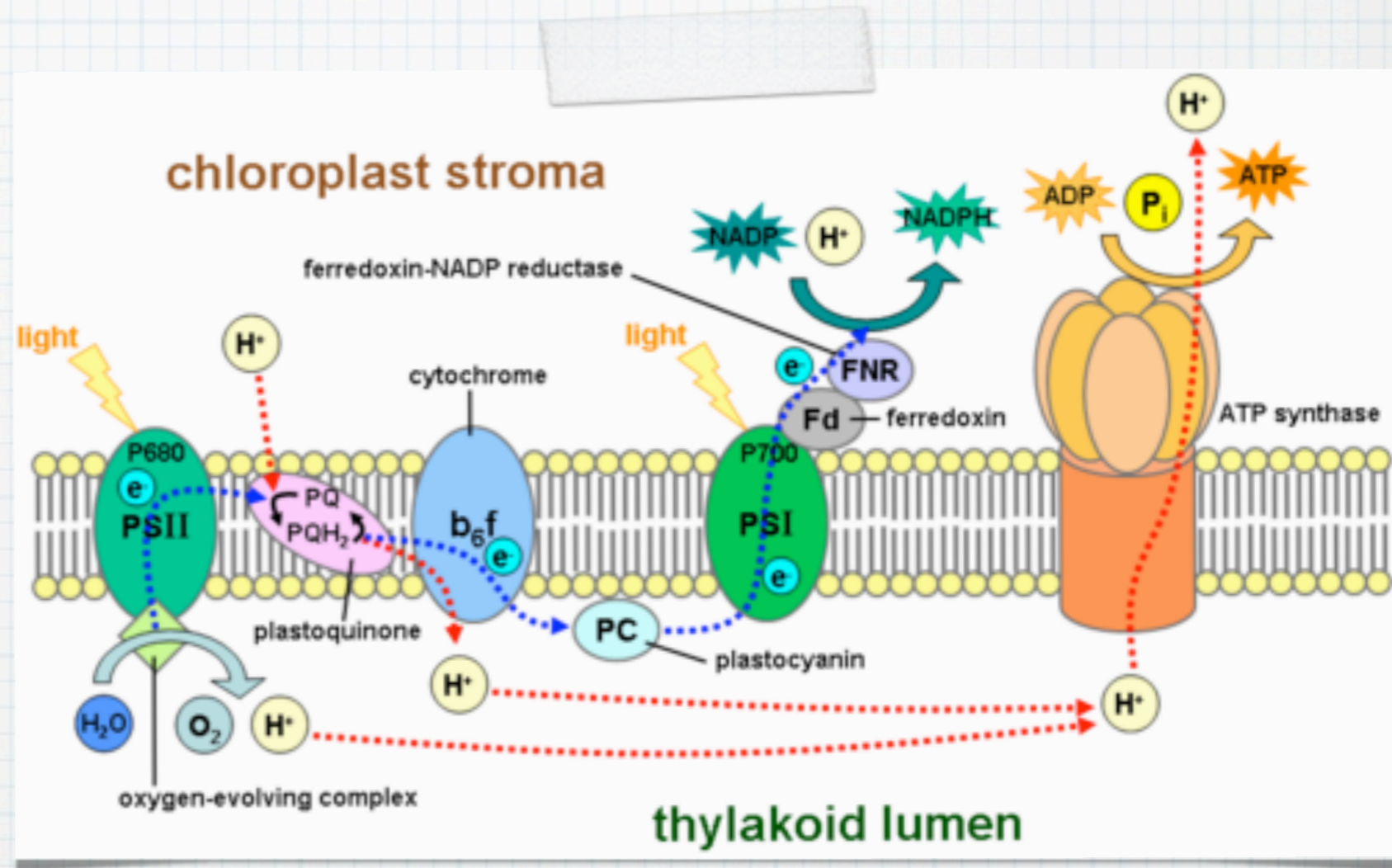
* In-Class Lab Activity: Chlorophyll Extraction

* <http://www.youtube.com/watch?v=keMssMr3aqw&feature=related>

Lesson 3: Photosynthesis: The Light Reactions

Topics Covered

1. Capturing Light Energy
 - Photosystems (P680 and P700)
 - antenna complex
 - reaction centre
2. Using captured light energy to make ATP and reduced NADP*



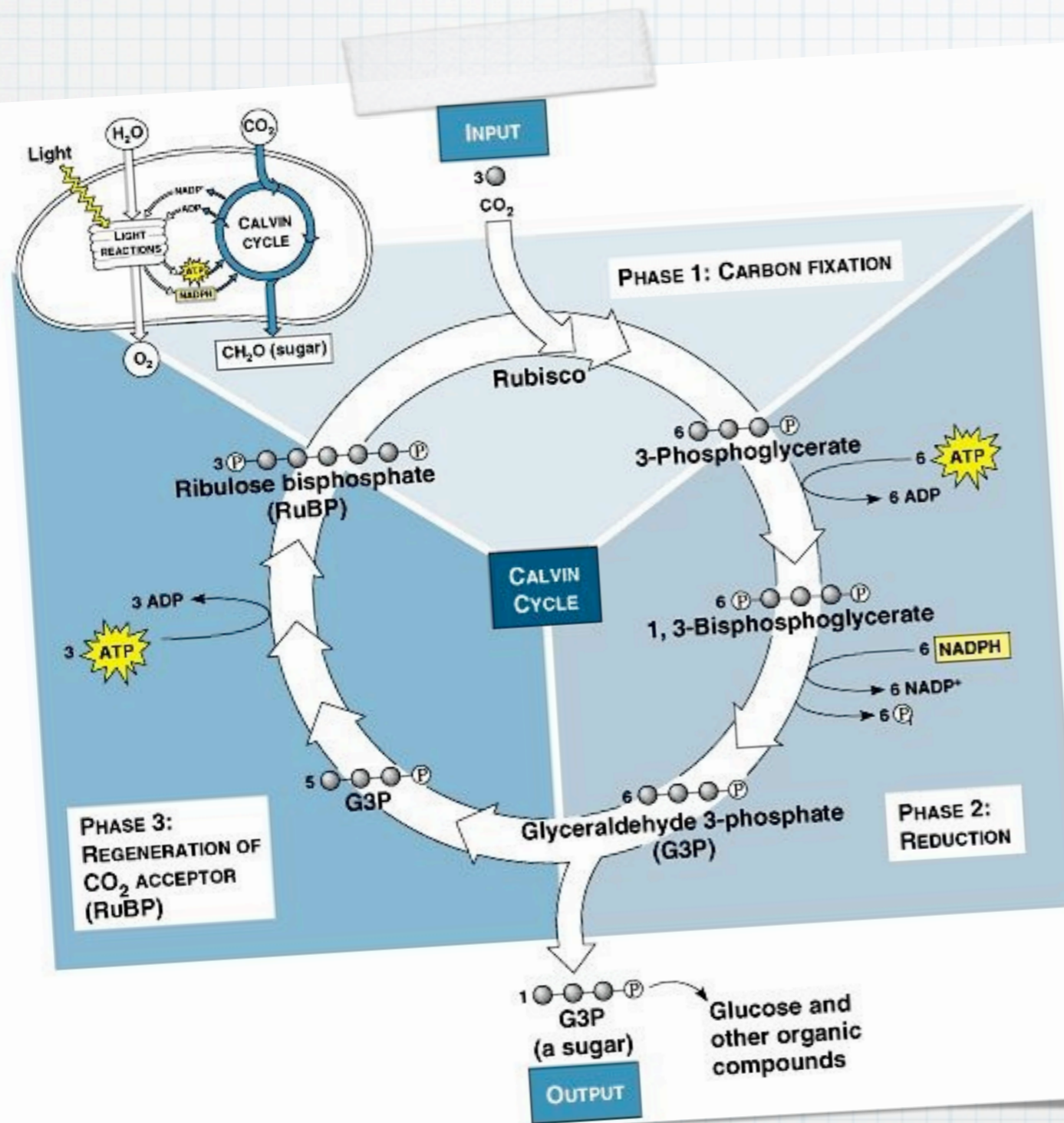
* The Light Reactions: http://www.youtube.com/watch?v=hj_WKgnL6MI

* Activity: Think-Pair-Share: What happens to photosynthesis when the sun is no longer out?

* Virtual Lab - Plant Pigment and Photosynthesis (Lab 1 - Chromatography; Lab 2 - Photosynthesis) (Assessment: Checklist)

http://www.phschool.com/science/biology_place/labbench/lab4/intro.html

Lesson 4: Photosynthesis: The Dark Reactions



Topics Covered

- * Using the free energy of ATP and the reducing power of NADPH to synthesize organic compounds, such as glucose, from CO_2

* The Calvin Cycle

1. Carbon Fixation
2. Reduction Reactions
3. RuBP Regeneration

* Alternative Mechanisms of Carbon Fixation

- C4 Plants
- CAM

Cooperative Activity: Create a flowchart on the process of photosynthesis

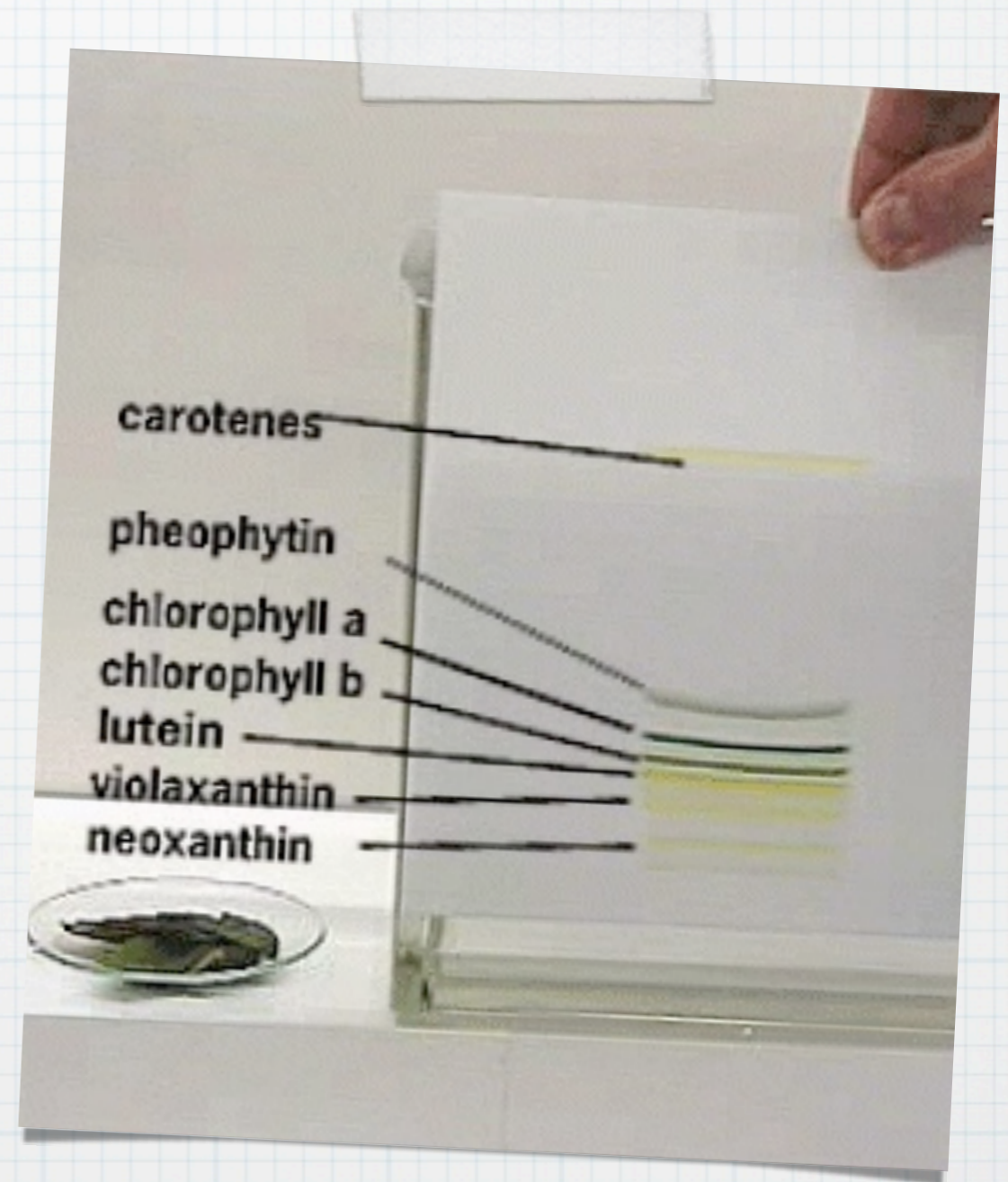
Activity: Factors Affecting the Rate of Photosynthesis

<http://www.neiljohan.com/projects/biology/rate-of-photosynthesis.htm>

Lesson 5: Photosynthesis and the Environment

Topics Covered

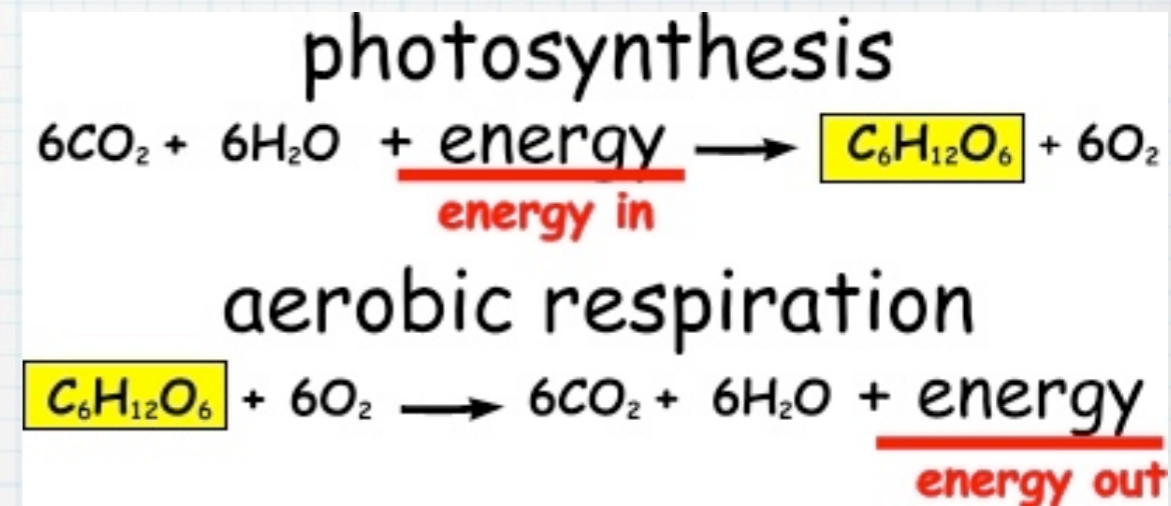
- * Net CO₂ uptake
- * Net O₂ evolution
- * Factors that affect the rate of photosynthesis in a plant
 1. Light Intensity
 2. Temperature
 3. Oxygen Concentration
 4. Photosynthetic Efficiency
- * **Summative Task:** Mini Quiz: Photosynthesis - Light and Dark Reactions (L3 and L4)
- * **Virtual Lab:** *Plant Pigment and Photosynthesis (Lab 1 - Chromatography; Lab 2 - Photosynthesis)*
http://www.phschool.com/science/biology_place/labbench/lab4/intro.html



Lesson 6: Photosynthesis vs. Cellular Respiration: Jeopardy Game

What is different and what is similar?

- * Comparison of the Overall Reactions (Respiration and Photosynthesis)
- * Electrons
- * Electron Transport System
- * ATP Synthesis
- * Organelle Structure and Function
 - * Mitochondrion vs. Chloroplast



Formative Assessment (Jeopardy Game): Teacher can use a game as feedback from students who understand the similarities and differences between the two reactions

Additional Activity: *Investigating Photosynthesis and Respiration through Kinesthetics and Inquiry*

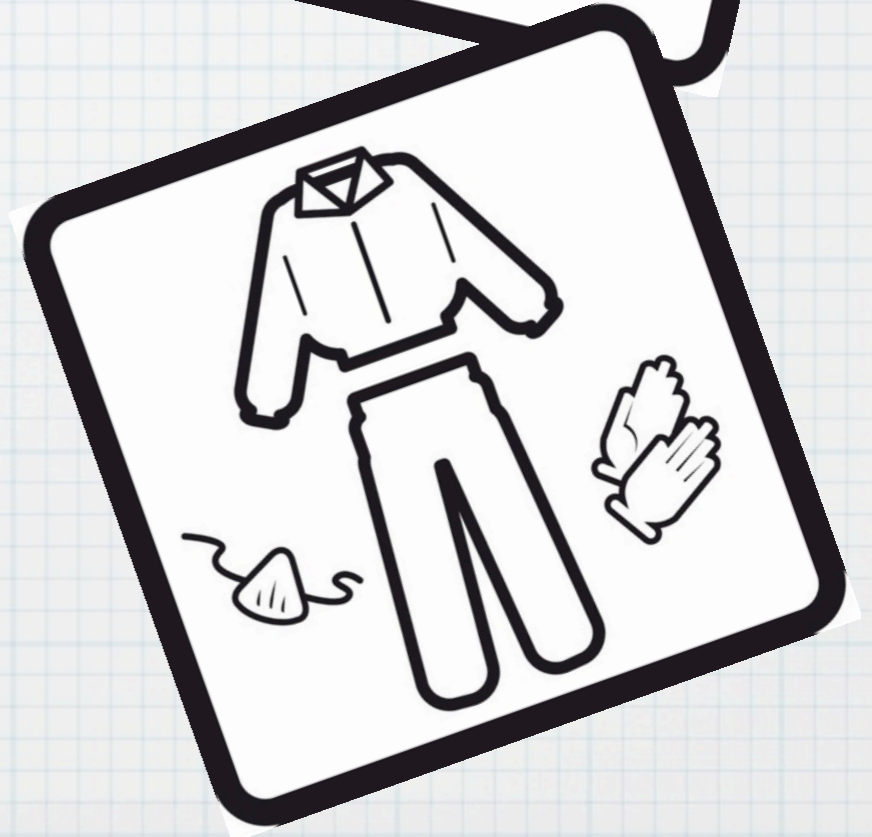
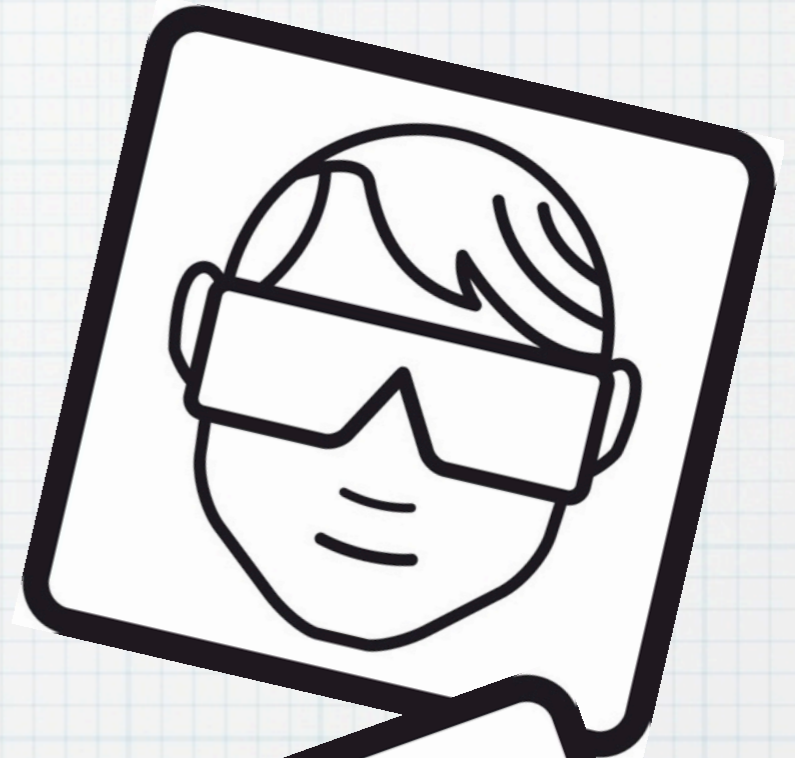
<http://www.the-aps.org/education/k12curric/activities/pdfs/carswell.pdf>

Safety Considerations for In-Class Experiments

* Experiment (L5): Chlorophyll Chromatography

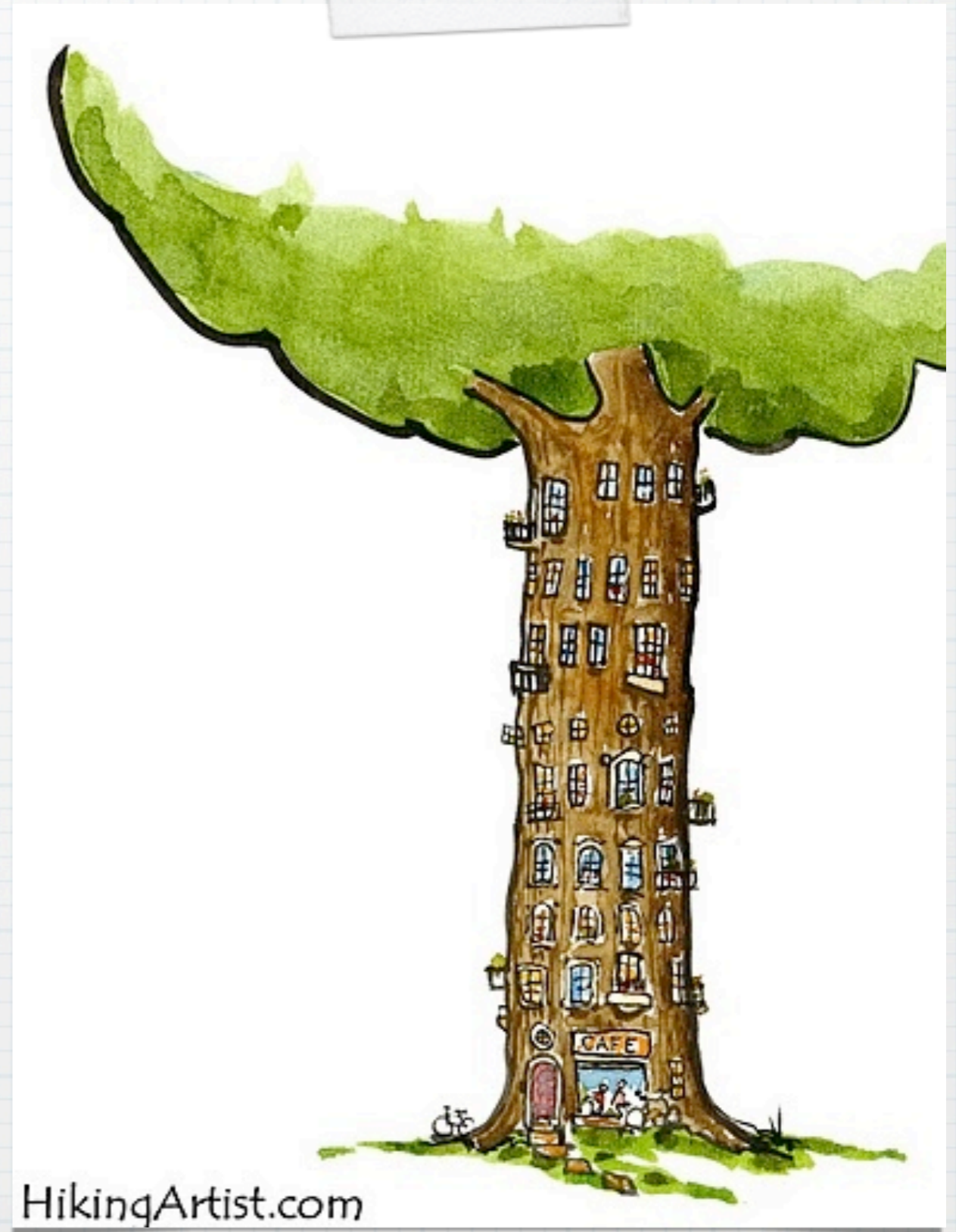
* [nstacommunities.org/.../LP_HS-Chlorophyll Chromatography Edited.doc](http://nstacommunities.org/.../LP_HS-Chlorophyll_Chromatography_Edited.doc)

- students must follow all lab protocol
- must wear goggles
- gloves and apron (if available) are optional
- if any glassware breaks, inform the teacher



Applications and Societal Implications

- * **Climate change** effects photosynthesis
 - Increasing levels of CO_2 increases the photosynthetic pathways, especially for C3 plants that are subjected to high temperatures and minimal water supply
 - Increasing levels of CO_2 also affects plant growth




Applications and Societal Implications (continued)








* Invasive Plants - Kudzu and Purple Loosestrife

- **Kudzu** - this North American northward moving invasive vine reduces biodiversity by rapidly overtopping and killing vegetation by shading
 - <http://www.youtube.com/watch?v=tiYrqucl2vg>
- **Hypothesis:** at suboptimal temperatures, the depressed photosynthetic rate negatively impacts growth
- **Purple Loosestrife** – this perennial herb is a hardy plant that is also an aggressive invader



Assessment and Evaluation

 Students are assessed almost everyday. This could be through the following (See Lesson Plan Overviews):

-  Question and answer during the lesson (diagnostic/formative assessment)
-  Short tests/quizzes - peer assessed or could be evaluated (summative assessment)
-  Homework exercises - could collect one question for understanding (formative/summative)
-  Mini activities – crosswords (formative/summative assessment)
-  Diagrams – Venn diagram, flow chart, etc. (formative/summative assessment)
-  Cooperative learning – Think-Pair-Share (formative assessment)
-  Games – Jeopardy (formative assessment)

References

*<http://www.ncbi.nlm.nih.gov/pubmed/15143433>

*<http://abstracts.aspb.org/pb2009/public/P22/P22002.html>

*nstacommunities.org/.../LP_HS-Chlorophyll_Chromatography_Edited.doc

*<http://www.taosschools.org/ths/School%20Improvement/CIEDipTTModule7TypesofFormativeAssessment.pdf>